Technical document

Computers examination

Restricted release to the safety investigation members

Document ID: **BEA2020-0308_tec01**
Registration number: **N55GJ**
Aircraft type: EUROCOPTER - EC130 - B4
Date of occurrence: 3rd August 2020
Place of occurrence: Fort Loudoun lake (Tennessee)
Equipment examined:

ECU (FADEC B) Thales P/N: 70BMF01000 S/N: 846	**VEMD** Thales P/N: B19030SA05 S/N: 1631
	

The VEMD (Vehicle and Engine Monitoring Display) is a multifunction screen installed on the instrument panel and designed to display flight data and engine data. The VEMD is a dual module system. In each module, failure information, associated to flight parameters, can be stored on a non-volatile memory component for maintenance purposes.
The relevant VEMD data for accident investigations are:

- Flight reports
- Failure messages with associated parameters
- Overlimits reports (overlimits are not dated).

The VEMD also records the last 8 Engine Power Checks (EPC) that are performed in flight to check the engine health according to the maintenance and flight manuals.

The ECU (Engine Control Unit) is a dual module computer performing fuel regulation and engine parameters management. On each module, failure blocks and some parameters, can be stored on a non-volatile memory component for maintenance purposes.
The ECU is connected to the VEMD; major failures, concerning the fuel regulation function, are transmitted by the ECU to the VEMD.

Work performed:

- **FADEC**

The computer was exposed to water during the accident. It was opened. The two main electronic boards were extracted (one per channel). They were visually inspected under magnification. The non-volatile memory components (one per channel) containing the recorded data were identified. They were in good condition.
The main electronic boards were dried for more than 48 hours at a temperature of 90°C.

The memory components were unsoldered using an infra-red rework station under temperature monitoring. They were cleaned, electrically characterized and read out using the BEA memory reader. The following binary files were generated:

- N55GJ_FADEC B_846_A-1.bin for channel A
- N55GJ_FADEC B_846_B-1.bin for channel B

The decoding of the ECU data was performed using the BEA dedicated software and the manufacturer's proprietary documentation referenced AA015378 issue B. The data were shared with Safran Helicopter Engines for analysis.

- **VEMD**

The computer was exposed to water during the accident. It was opened. The two main electronic boards were extracted (one per channel). They were visually inspected under magnification. The non-volatile memory components (one per channel) containing the recorded data were identified. They were in good condition. The main electronic boards were dried for more than 48 hours at a temperature of 90°C. Due to the results of the work on the FADEC B and as the failure records in the VEMD are the same than the failure records in the FADEC, it was decided not to perform any further work.

Results:

- **FADEC**

Safran Helicopter Engines shared a document: 2020-187_analyse_dump_uk.pdf with the result and their analysis.

- *Channel A:*

The last recorded flight (PON 103192) was associated with the flight of the event thanks to the duration. Four failure blocks were recorded with associated parameters.

Time since power-up	Failure	Internal failure or failure from sensor
4991 (1 h 23 min 11)	PANNE_CONVERSION_VOIE_B_NON	Internal
	PANNE_T4_NON	Sensor
	PANNE_XPC_OUI	Sensor
	PANNE_NTL_OUI	Internal
4994 (1 h 23 min 14)	PANNE_ARINC_HELICO_OUI	Internal
	PANNE_T4_OUI	Internal
	PANNE_ECM_OUI	Internal
	PANNE_XPC_OUI	Internal
	PANNE_NG_OUI	Internal
	PANNE_NTL_OUI	Internal
5001 (1 h 23 min 21)	PANNE_CONVERSION_VOIE_A_NON	Internal
	PANNE_ARINC_HELICO_OUI	Internal
	PANNE_T1_OUI	Sensor
	PANNE_T4_OUI	Sensor
	PANNE_P3_OUI	Internal
	PANNE_ECM_OUI	Internal
	PANNE_XPC_OUI	Sensor
	PANNE_XTL_OUI	Internal
5006 (1 h 23 min 26)	PANNE_CONVERSION_VOIE_A_ NON	Internal
	PANNE_ARINC_HELICO_OUI	Internal
	PANNE_T1_OUI	Sensor
	PANNE_T4_OUI	Sensor
	PANNE_P0_OUI	Internal
	PANNE_P3_OUI	Sensor
	PANNE_ECM_OUI	Sensor
	PANNE_XPC_OUI	Sensor

- *Channel B:*

The last recorded flight (PON 24966) was associated with the flight of the event thanks to the duration. Seven failure blocks were recorded with associated parameters.

Time since power-up	Failure	Internal failure or failure from sensor
4991 (1 h 23 min 11)	PANNE_XPC_OUI	Sensor
	PANNE_NTL_OUI	Internal
4993 (1 h 23 min 13)	PANNE_T4_NON	Sensor
	PANNE_ECM_OUI	Internal
	PANNE_XPC_OUI	Internal
	PANNE_NG_OUI	Internal
	PANNE_NTL_OUI	Internal
4995 (1 h 23 min 15)	PANNE_T4_OUI	Internal
	PANNE_ECM_OUI	Internal
	PANNE_XPC_OUI	Internal
	PANNE_NG_OUI	Internal
	PANNE_NTL_OUI	Internal
5000 (1 h 23 min 20)	PANNE_T1_OUI	Sensor
	PANNE_T4_OUI	Sensor
	PANNE_ECM_OUI	Internal
	PANNE_XPC_OUI	Sensor
	PANNE_XDOS_OUI	Internal
	PANNE_NG_OUI	Internal
	PANNE_NTL_OUI	Internal
5002 (1 h 23 min 22)	PANNE_CONVERSION_VOIE_A_NON	Internal
	PANNE_T1_OUI	Sensor
	PANNE_T4_OUI	Sensor
	PANNE_P3_OUI	Internal
	PANNE_ECM_OUI	Internal
	PANNE_XPC_OUI	Sensor
	PANNE_XTL_OUI	Sensor
	PANNE_XDOS_OUi	//
5004 (1 h 23 min 24)	PANNE_CONVERSION_VOIE_A_NON	Internal
	PANNE_T1_NON>	Sensor
	PANNE_T4_OUI	Sensor
	PANNE_P0_NON	Internal
	PANNE_P3_OUI	Sensor
	PANNE_ECM_OUI	Sensor
	PANNE_XTL_OUI	Sensor
	PANNE_XDOS_OUI	//
5007 (1 h 23 min 27)	PANNE_CONVERSION_VOIE_A_NON	Internal
	PANNE_T1_OUI	Sensor
	PANNE_T4_OUI	Sensor
	PANNE_P0_OUI	Internal
	PANNE_P3_OUI	Sensor
	PANNE_ECM_OUI	Sensor
	PANNE_XTL_OUI	Sensor
	PANNE_XDOS_OUI	//

- *Failure description*

Each failure message contains the information _NON or _OUI at the end of the message name. The meaning is as follows:

- _NON means the message is issued by the Operating Software. The message is not received or confirmed by the Applicative Software (engine control software) and therefore is not recorded in the ECU unless another confirmed failure is encountered. The control system continues to operate in normal automatic mode.
- _OUI means the message is confirmed by the Applicative Software (engine control software). It is recorded in the ECU as soon as triggered.

PANNE_CONVERSION	This message is issued by the operating software. It is the result of the analogue-to-digital conversion monitoring process conducted by the operating software during the self-test of the DECU at power-up. This message is neither received nor confirmed by the engine control software and therefore is not recorded in the DECU unless another discrepancy is encountered. This has no effect on engine control.
PANNE_XPC	This message indicates that the collective pitch (XPC) measurement has reached an out-of-limit value (mini, maxi or gradient). The control system then triggers an amber "GOV" signal that indicates a "degraded" automatic operation of the control system which takes a back-up law for the collective pitch values. The control system remains in automatic mode. This message is often encountered in an impact sequence.
PANNE_T4	This message indicates * A loss of redundant T4 (Turbine outlet Temperature) information from the aircraft monitoring system (if any) * Or that the T4 measurement has reached an out-of-limit value (mini, maxi or gradient). The control system then triggered an amber "GOV" signal that indicated a "degraded" automatic operation of the control system, which takes a back-up law for the T4 values.
PANNE_NTL	This message indicates that the NTL (free turbine speed) measurement has reached an out-of-limit value (mini, maxi or gradient). Deprived from NTL valid value, the control system then triggered a red "GOV" signal that indicated the ECU handed the fuel flow control over to an external auxiliary system on aircraft side.
PANNE_ARINC_HELICO	This message indicates no reception of the ARINC message sent by the VEMD or incorrect message received. Consequences: loss of redundant information (P0_helicopter and T0_helicopter) without any effect on the engine control in automatic mode. Loss of the information T0_helicopter which takes back-up values. In this case, in normal operation, the control system indicates amber "GOV" which means a degraded operating mode of the control system. The control system keeps controlling the engine in automatic mode.
PANNE_ECM	This message is related to the TQ (torque) conformation and indicates that the torque measurement has reached an out-of limit value (mini, maxi or gradient). The control system then triggered an amber "GOV" signal that indicated a "degraded" automatic operation of the control system, which takes a back-up law for the torque value. If it occurs in flight, it has no effect on the engine control system.

PANNE_NG	This message indicates: Loss of one of the NG (gas generator speed) measurement. This loss of redundancy is without any effect on the engine control system. Or the NG (gas generator speed) measurement has reached an out-of-limit value (mini, maxi or gradient). The control system then triggers a red "GOV" signal that indicates that the ECU stops controlling the fuel flow which has then to be managed manually by the pilot.
PANNE_T1	This message indicates that the T0 measurement has reached an out-of-limit value (mini, maxi or gradient). The control system then triggered an amber "GOV" signal that indicated a "degraded" automatic operation of the control system, which takes a back-up law for the T1 values. The control system remains in automatic mode.
PANNE_P3	This message indicates that the P3 measurement has reached an out-of-limit value (mini, maxi or gradient). The control system then triggered an amber "GOV" signal that indicated a "degraded" automatic operation of the control system, which takes a back-up law for the P3 values.
PANNE_XTL	This message indicates that the Trim NTL measurement has reached an out-of-limit value (mini, maxi or gradient). The control system then triggered an amber "GOV" signal that indicated a "degraded" automatic operation of the control system, which takes a back-up law for the Trim NTL values. In this case, in normal operation the pilot cannot adjust the NTL speed. The control system remains in automatic mode.
PANNE_P0	This message indicates a discrepancy with the P0 signal received via the ARINC link. The ECU then refers to a back-up value of P0. The control system remains in automatic mode.
PANNE_XDOS	This message indicates a discrepancy of the resolver's sensor. If it occurs in flight, the control system continues to ensure the engine control in automatic mode and indicates an amber "GOV" signal.

- *Analysis of the failure of the collective pitch anticipator potentiometer (XPC)*

A failure of the collective pitch anticipator potentiometer position is triggered when the measurement of the relative position of the potentiometer reaches its minimum (5%) or maximum (95%) thresholds or when its variation is above 350% per second. Apart from a failure of the sensor or from the unusual displacement resulting from the consequences of an accident/impact, these thresholds cannot be mechanically reached because of the collective pitch system design.

The position of the collective pitch anticipator potentiometer is used by the ECU for power anticipation in order to maintain rotor speed within an acceptable range. In case of failure, the ECU remains in an automatic mode and takes a back-up law for the collective pitch values.

According to BEA, Airbus Helicopters and Safran Helicopter Engines experience, the failure of collective pitch anticipator potentiometer is one of the first failures recorded in the sequence of failures following an impact with the ground/water surface.

For both channel, the XPC message appears in the first block thus indicating that there were no recorded failures in flight prior to the impact.

- *Analysis of the associated parameters*

For all the failure blocks, the associated parameters are described and analysed in Safran Helicopter Engines document: 2020-187_analyse_dump_uk.pdf.

The logical words in binary could be decoded. The most interesting one is the one corresponding to the inputs just before the first failure. It indicates that the helicopter was in flight.

Conclusion:

Both channel of the ECU recorded several failures (including the failure of the collective pitch anticipator potentiometer – XPC) related to various independent chains and occurring within a short period of time. All the failures were most probably the consequence of the impact with the water.

Document provided:

- Binary files:
  - Channel A: N55GJ_FADEC_B_846_A-1.bin

SHA256 print: 75736BB0DEC180F2AD9B4D14189FF55E4AC4D1EED4F03D397B988DF4B45C2D7F
Size: 32 KB

  - Channel B: N55GJ_FADEC_B_846_B-1.bin

SHA256 print: F5CA2450BD1F5C26B9F39E475D9BF9E9C6FDB8CA74F6785F9D5361CA0337B2E9
Size: 32 KB

- Decoded files and associated parameters
  - Channel A: N55GJ Channel A.rar
  - Channel B: N55GJ Channel B.rar
- Safran Helicopter Engines analysis: 2020-187_analyse_dump_uk.pdf